1-1-2009

IS solution for the global environmental challenge: an Australian initiative

Trevor A. Spedding
University of Wollongong, spedding@uow.edu.au

Aditya K. Ghose
University of Wollongong, aditya@uow.edu.au

Helen M. Hasan
University of Wollongong, hasan@uow.edu.au

IS solution for the global environmental challenge: an Australian initiative

Abstract

There is a complex range of interrelated environmental issues that currently challenge decision-makers across the world. To date the reputation of the information and communication technology (ICT) industry in Australia, and elsewhere, has been quite negative with respect to its effect on the environment. The recent "Green IT" initiatives of the Australian Computer Society to reduce carbon emission are manifestations of this. While not denying the worth of this agenda, the authors of this paper suggest that it is timely to promote a more positive position for ICT as a source of solutions to environmental problems. In this paper, we draw on the Australian experience and our own research into various ICT-tools, to map out the territory where these solutions may be found and to identify first steps in their implementation.

Keywords

global, solution, australian, challenge, environmental, initiative

Disciplines

Physical Sciences and Mathematics

Publication Details

Hasan, H. M., Ghose, A. K. & Spedding, T. A. (2009). IS solution for the global environmental challenge: an Australian initiative. Proceedings of the Fifteenth Americas Conference on Information Systems: AMCIS2009 (pp. 1-7). San Francisco, California: San Francisco State University.

Americas Conference on Information Systems (AMCIS)

AMCIS 2009 Proceedings

Association for Information Systems *Year* 2009

IS Solution for the Global Environmental Challenge: An Australian Initiative

Helen Hasan* Aditya Ghose†

Trevor Spedding‡

*University of Wollongong, hasan@uow.edu.ac

†University of Wollongong, aditya@uow.edu.au

‡University of Wollongong, spedding@uow.edu.au

IS solutions for the Global Environmental Challenge: an Australian Initiative

Helen Hasan
Faculty of Commerce, University of Wollongong
hasan@uow.edu.au

Aditya Ghose
Faculty of Informatics, University of Wollongong
aditya@uow.edu.au

Trevor Spedding
Faculty of Commerce, University of Wollongong
spedding@uow.edu.au

ABSTRACT

There is a complex range of interrelated environmental issues that currently challenge decision-makers across the world. To date the reputation of the information and communication technology (ICT) industry in Australia, and elsewhere, has been quite negative with respect to its effect on the environment. The recent 'Green IT' initiatives of the Australian Computer Society to reduce carbon emission are manifestations of this. While not denying the worth of this agenda, the authors of this paper suggest that it is timely to promote a more positive position for ICT as a source of solutions to environmental problems. In this paper, we draw on the Australian experience and our own research into various ICT-tools, to map out the territory where these solutions may be found and to identify first steps in their implementation.

Keywords

Climate change, environment, information systems, IT solutions.

INTRODUCTION

Environmental concerns that threaten the very existence of the human race are arguably the most important issues of our time. There is a complex range of interrelated environmental issues that currently challenge decision-makers at local, national and international levels and our Australian experience is no different. Information and communication technology (ICT), in particular the World Wide Web, has greatly increased the public availability of information from a wide range of sources on the science, economics and politics of these critical issues and hence impacted on the global awareness of the challenges to be faced. A second impact of ICT is the appropriation of the Web, in particular the social technologies of Web 2.0, for network-centric advocacy through which globally disparate communities can connect and coordinate activities to influence business and government. Because of these two areas of social impact, we argue that the Information Systems (IS) community is already a player in the global response to environmental challenges. What is more, the IS professionals can, and in our opinion, should contribute their particular expertise to the current discourse and promote itself as a source of solutions to these challenges.

To date, the reputation of the IT industry has been quite negative with respect to its effect on the environment. The Australian Computer Society has released a Policy for Green IT (ACS 2006) that essentially regards ICT as a polluter that needs to find ways to reduce its carbon footprint. This negative view is supported by active lobbyist groups such as Computer's Off Australia[1]. There is however an opportunity to reverse this direction now that a newly elected federal government has placed Climate Change high on the national agenda. The authors of this paper suggest that it is timely here and elsewhere to promote a more positive position for ICT as a source of solutions to environmental problems.

In this paper, we present the findings of a multidisciplinary group who have set out to map out the territory of the Climate Change challenge, for which IS could be responsible, and to propose a way forward. This is not only a challenge worth addressing for the sake of the environment but also offers a real opportunity as an exciting new direction for the IS discipline A series of focus groups, workshops and panels have been conducted to map out a role for the field of IS in this area, to identify a range of potential IS solutions to climate change problems and to set an agenda for implementation of these solutions. The initiative began with a group of three researchers from the fields of IS, computer science, and management

[1] http://www.computersoff.org/

then expanded into a larger reference team which include members from law, economics, engineering, socio-technical studies, and communications studies as well as industry representatives. Writing this paper is one of the activities of the group and others are described below. Just as this area requires new research approaches, so this paper takes a non-standard approach to reporting and interpreting research.

BACKGROUND TO THE AUSTRALIAN EXPERIENCE

In the context of the current environmental crisis, Australia holds a unique position in the southern hemisphere as an island continent roughly the size of the US. However, with less that one twelfth the population of the US, a relatively number of people have a large area of the planet for which we are responsible. Australia is one of the oldest and driest places on earth with distinctive species of flora and fauna. We have for some time been concerned with the ramification of environmental issues including scarcity of drinkable water and arable land; depletion of the Ozone layer; deforestation; increasing acidity of oceans and salination of soil, destruction of eco-systems and species extinction. However, the highest profile, most urgent and most complex of our environmental challenges is the potential impact of climate change due to the emission of greenhouse gases into the atmosphere. Close to growing economies in Asia, Australians have benefited from this market for our immense deposits of coal and minerals providing much of our current wealth. It also provides a relative cheap source of energy for our own industry but its use means we have a large C foot print per capita. As a developed western country we have the capability to redress this and our knowledge in the field of IS should be part of this endeavor.

Following the release of the Stern Report in the UK (Stern 2006) and the Al Gore documentary (Gore 2006), climate change has held centre stage on the international arena. In Australia they engendered popular support for tackling the problems with a growing frustration at our government's inaction. As in the US, Australia resisted ratifying the Kyoto Protocol despite the fact that our targets under this scheme are being met. However, in late 2007 federal elections resulted in a change of the majority political party. Signing up to the Kyoto Protocol became the first act of the new government, an act which was supported by popular opinion and signaled an intention to take a more proactive stance toward environmental issues. Australian governmental attention is now being given to policies and actions that will reduce emissions, develop alternative sources of energy, and change our ways doing things to mitigate against the problems of climate change. However attention to this topic is particular timely in Australia and New Zealand with the rapid acceleration of relevant government initiatives in 2008, which are framing unprecedented public debate.

In Australia, a National Greenhouse and Energy Reporting Scheme (DCC 2008) came into effect on 1 July 2008 and we are already seeing the response to that, for example, in our own Universities' green initiatives. July 2008 also saw the release of the Carbon Pollution Reduction Scheme Green Paper, which not only canvassed options and preferred approaches on how emission caps will be set but also ways to address the impacts on Australian households, emissions-intensive trade-exposed industries and other strongly affected sectors. The Government plans to commence the Emissions Trading Scheme (ETS) in 2010 and is keen to ensure the Carbon Pollution Reduction Scheme and accompanying household and business support is consistent with the productive capacity of the economy. The policy is guided by the Garnaut Climate Change Review (Garnaut 2008) which released its Final Report on 30 September 2008 following the Draft and Supplementary Draft Reports released in June 2008.

WHERE IS 'IS' ON THE CLIMATE CHANGE ISSUE?

In mapping out the whole climate change landscape we have found it appropriate use the following three categories:

- The science of climate change, which, although controversial, is the stimulus for the other two categories.
- The research, development and engineering of technical measures to reduce carbon emissions, such as cleaner and renewable sources of energy, more energy efficient devices, design of carbon neutral buildings and cities. Much of the current 'Green IT' program fits here.
- The set of processes, infrastructures, organization and politics that will support and enable the required massive changes to the lives of individuals, communities, businesses and nations. ICT and IS are critical to this category, providing tools for monitoring, modeling, communication, coordinating, visualizing, advocating and predicting. Our paper addresses this category.

Despite many decades of lobbying by scientists and environmental groups, climate change has only really captured the attention of national leaders over the past couple of years. It is interesting to speculate that one the reasons why is the Internet. The Internet emerged as an 'Information super highway' with exponential increases in uptake during the 1990s. Almost overnight people throughout the world became interconnected by a technological infrastructure that was flexible, malleable, accessible, and, in most places, not controlled or planned. People everywhere contributed to the development of

what this global information system could do and who could do it. In the 21st Century it costs very little to have a presence on the World Wide Web, to do global business from home, to post text, pictures, video for all to see and to collaborate with friends and strangers to create and publish knowledge.

The capability of ICT to process information and knowledge and to support communicate is unprecedented. The largely unanticipated and even unnoticed consequence of Internet has been the exponential growth of World Wide Web resulting in:

- Increased global and ubiquitous availability of information.
- Diverse sources and forms of information.
- The ability to share knowledge and to co-create repositories of knowledge.
- Democratization of information and knowledge, with a loss of power of the traditional guardians of knowledge.
- Web-based applications, allowing an inexpensive, open, and democratic basis for discussion and negotiation.
- The resulting influence of geographically dispersed advocacy groups on the visibility of knowledge, galvanizing public opinion and influencing political responses.

Climate change and environmental sustainability are issues where information and knowledge are vital, and social and cultural elements are critical. Advocacy groups on all sides of the debate are using ICT, the WWW and associated media to promote their causes. The world is an avid consumer of each new digital tool or toy and yet it seems that the IS discipline is not excited by the impact that this is having on social and cultural lives. Equally there is little apparent enthusiasm for the idea that the IS discipline may contribute solutions in general Climate Change discussions and promote itself as relevant to the real problems of the 21st Century.

'IS for climate change' is an emerging topic where specific literature is scarce. The topic has been explicitly addressed in a chapter developed as part of the global IS text project edited by Rick Watson (Boudreau et al 2008). Here the term 'Green IT' is distinguished from 'Green IS'. 'Green IT' is seen to focus mainly on energy efficiency and equipment utilization. 'Green IS', in contrast, refers to "the design and implementation of information systems that contribute to sustainability of business processes". The authors give examples such as reducing transportation costs, supporting teamwork and meetings, tracking environmental information, monitoring a firm's operational emissions and waste, and providing information to consumers. Green IS, as so described, should therefore have a greater potential than Green IT because it tackles a much larger problem.

A more positive message supporting this position can be found in the work of Romm et al (1999) who noted at that time that the Internet economy was generating both structural and efficiency gains leading to emission reductions. Fuhr and Pociask (2007) recently reported on a study determining reduction in greenhouse emissions through the wide delivery of broadband services in the US and more recently the work of Fernandez et al (2008) on how IS design can support and coordinate a project to extract oil from green algae. This message is also driven home in the Smart 2020 project (GeSI 2008), and a UN media release (UN 2007). However, literature in this area is scarce and there is certainly potential and a need for more.

MAPPING OUT THE TERRITORY

The key motivation for the initiative is the conviction that many aspects of IS research have the potential to provide climate change solutions. Several brainstorming sessions of our reference team have identified the following areas of IS expertise that fit into the solutions for climate change agenda.

End-user planning and monitoring tools

One of the catch cries of the environmentalists is to 'think globally and act locally'. This puts the responsibility for action onto individual citizens, many of whom are keen to contribute, but need knowledge and capability to do so. Simple IS tools such as check lists, fact sheets, carbon calculators, and product labeling can encourage and support this effort. This may seem trivial to an IS researcher but is a cost effective way to empower individuals to be greener not only at home but also in small businesses and work units. As a small step in our initiative, we are collecting links to such information for easy access through our website. The positive messages that come from this are:

- Most simple green measures also reduce costs (recycling, reducing energy consumption etc)
- Greener businesses are more attractive customers and to potential Gen Y employees
- Going green feels good.

Optimization Information Systems

Optimization has been a fundamental component of the global business vocabulary since the 1940s, when George Dantzig proposed *linear programming*, the first in a long line of operations research/optimization techniques that have delivered significant value in both design and operational efficiencies to organizations of various kinds. Optimization techniques have helped design efficient layouts for manufacturing and warehousing facilities in complex supply chains, devised efficient production plans for manufacturers, optimized production schedules in a shop-floor environment, produced optimal logistics plans for the shipment of goods, generated efficient crew rosters and even informed the design of large-scale public infrastructures such as highway networks, urban layouts etc. Optimization techniques encode problems in terms of real-world *constraints* that any solution must satisfy, and an *objective function* that encodes organizational/operational/design objectives (such as maximization of profit, minimization of cost, maximization of asset utilization etc.). Examples of optimization studies that demonstrate its potential application as climate change solutions are described by Harvey et al (2006) and Ghose and Koliadis (2007).

The climate change crisis provides an implicit incentive for organizations to optimize their operations, but poses a major managerial challenge. Organizations must work with limited budgets for the deployment of optimization systems, and must therefore be judicious in deciding where and how to invest in optimization technology along their entire supply chain. The *Supply Chain Optimization Audit (SCOA)* methodology under development by one of the authors provides a principled basis for these decisions and helps organization identify the "low hanging fruit", from a carbon footprint minimization perspective, that would provide the best 'return' (not merely in the traditional sense, but also in the sense of 'green returns') on investment in optimization systems.

Another concept under investigation is that of the *Optimizing Web* which seeks to design and build such an 'optimization-in-the-large' facility by leveraging the existing infrastructure of the world-wide web. The proposition is to add an additional dimension to the web – one that would enable *distributed continual optimization* over a globally deployed *web of optimizers* (an optimizer, here, refers to an automated system that provides decision support in determining solutions to an optimization problem). This model envisages very large-scale networks of optimizers deployed at varying levels of granularity on individual devices, at the level of households, on vehicles, and in even more complex ways throughout the industrial infrastructure. An individual optimizer would seek to optimize the behavior (and thus, the carbon footprint) of the entity it manages, but would also seek to influence the behavior of other entities that it interacts with in ways that would help it optimize relative to its local objectives (these would ideally be engineered to be *in alignment* with a global carbon footprint minimization objective).

Computer-based simulation models

Few companies with a large carbon-footprint exhibit the capacity or will to utilize technologies that provide computer-aided analysis of sustainable manufacturing and environmental management in the enterprise. Computer-based simulation models are used to provide a virtual snapshot of an enterprise (and its supply chain) so that a holistic view can be developed. This facilitates an integrated systems dynamics approach so that the sustainable, environmental and economical aspects of an enterprise can be investigated.

In industry, there are usually three generic performance concerns that have to be balanced in simulation modeling for the sustainable enterprise: productivity, quality and cost. In order to remain competitive, it is important to lower cost while increasing productivity and improving quality. A sustainable enterprise must however consider the extra and equally important dimension of the environment. Environmental issues, such as reducing waste from the production stream, must be closely associated with the production and economic aspects of the product, such as reducing costs.

The industrial system, consisting of activities which have complex interrelations and random processes, has a two-way interaction with its environment and therefore its activities will affect the environment. The areas of concern in the pursuit of applying sustainable manufacturing may be summarized as follows:

- the need to quantify and measure environmental issues within industry, in terms of a business case: i.e. costs, quality and productivity;
- the need to integrate environmental issues (such as pollution and waste), and economic issues (in terms of total costs);
- the importance of seeing the whole, that is, to see from beginning to end the activities making up a system (both within each component of a supply chain and between each element of the end to end supply chain);
- and finally, the development of a tool that can be used to apply a systems approach and integrate all the requirements stated above.

The advantage of using this approach is that it can incorporate past and present data to accurately represent a dynamic and holistic view of an enterprise as it is currently operating. The model can then be "fast forwarded" into the future to investigate the implications of various operational and strategic decisions on a comprehensive set of performance indicators and environmental measures. Simulation tools effectively integrate sustainable issues and costs into a unified framework to demonstrate that sustainability is not only free, but may also save costs in the long run (see for example Hsien et al 2006 and Taplin et al 2006).

Really Going Paperless

Despite the decades-old promise of the paperless office, ICT has greatly increased our use of paper in many areas (Sellen & Harper 2001). There are signs that the tide is now turning with the popularity of e-business, online surveys, document readers, tracking facilities in word processors, e-books, online news, digital archiving, photo display devices and so on. There is still however resistance in some quarters to these technologies and the climate change argument should join those of lower cost and better quality in encouraging wider adoption of paperless procedures. Research is still needed into increasing utility, usability and user acceptance of e-tools.

ICT-enabled conferencing and collaborating

For human enterprises to perform effectively, they need to develop social capital by meeting, coordinating, communicating and collaborating. Traditionally, people have preferred to meet face-to-face (F2F), to have a daily routine where they 'go to work', to read printouts rather than the screen and so on. However we now recognize that such activities have a significant carbon footprint, traveling, and commuting. Potential IT solutions to these problems have been around for some time, namely teleconferencing, telecommuting, the virtual office, and group decision support systems. Despite research showing their benefits and effectiveness (see for example Hasan 2005 and Hasan & Crawford 2007) their take up has not been particularly widespread as people have resisted the combination of technical, economic, social and cultural changes to the way things are done. Putting the 'C' (communication) into ICT, together with the new imperative to take environmental concerns into account, and the ICT-enabled conferencing and collaborating tools are now firmly back on the agenda.

There are several topics where research is still needed into the relationship of social issues and technology. Examples of these include:

- Getting the balance right for people telecommuting or working at home between manager who have concerns that employees work less and employees who may overwork and have poor work/life balance
- Meeting virtually: The widely used teleconferencing is a rather poor medium but can have support facilities such as common whiteboards, slide shows. On the other hand, Video conferencing was once very costly but is now cheaper and available on the desktop over IP. Some companies now even support meeting in richer virtual worlds such as second-life
- The virtual office: In some organizations, sales teams no longer use a central office – meeting in cafes with simply laptops and wireless internet connection and many client meetings take place in homes.

Network-Centric Advocacy and Government Policy

The public voice on environmental issues and climate change is multidisciplinary and cross cultural, with different languages and jargon and foci. Supported by Web 2.0, the balance of power with respect to knowledge is now shifting from the 'official versions' in the hands of governments, big business, media moguls, formal libraries and publishing houses. Now if anyone wants to 'know' they are more likely to go to Google or Wikipedia. Many, particularly young, consumers of news are cynical about what they read in newspapers or see on television. They read blogs from people on the scene, get personal opinions from postings on Myspace or Facebook, become immerse in virtual worlds on Second Life, interact on Twitter, see pictures on Flickr or videos on Youtube. This has democratized knowledge and provided a form of network-centric advocacy which is changing the political landscape. Voters are now exposed to new perspectives on issues and are able to collaborate with others to get new messages out there. This phenomenon is almost certainly helping the environmental movement with knowledge sharing and network-centric advocacy and should be a part of the concerns of the social impact of IS.

Australian industry will need to be prepared to participate in a carbon Emissions Trading Scheme (ETS) within the next several years. The ETS is intended to serve as a macro-economic lever to incentivize organizations to reduce their carbon footprint. A fundamental pre-requisite of carbon footprint reduction is operational efficiency – this can only be achieved through the judicious use of optimization technology and the development of a pervasive optimization-oriented mindset. While the benefits of operational efficiencies are self evident, large portions of Australian industry is not aware of the potential for optimization technologies, or the immediate returns that accrue from an optimization-oriented mindset. The ETS

will serve as a *major* incentive for the deployment of optimization technologies and the holistic understanding of the operation of organization and supply chains can be gained through modeling using systems thinking. The results of this work are able to show managers that they can have, and how they can have, sustainability with environmental responsibility. In addition to optimizing operations, organizations can improve their sustainability with the use of ICT for communicating, collaborating, coordinating, and cooperating with a decreased in their carbon foot print.

A PROPOSED STRATEGY

Focus groups and planning meetings of the authors with our reference team are proposing, and have begun to implement, a strategy to promote research and practice in the area we are calling 'carbon-centric-computing'. Following the philosophy to think globally and act locally we decided to leverage our own fields of expertise and the current national interest in climate change to apply for support from our local institution to set up an initiative with the following objectives:

1. Provide thought leadership to highlight the role of ICT as a source of climate change solutions.
2. Seed the development of a new sub-discipline within computing science and IS (carbon-centric computing).
3. Focus attention on research challenges in this sub-discipline begin creative in the way creative and multidisciplinary approaches are applied to this research.
4. Introduce a new environmentally aware dimension for evaluating/interpreting a wide spectrum of IT research, development and practice.
5. Broker a partnership with industry and government to develop a range of high-impact solutions within this space.
6. Set a curriculum for education, with an emphasis on executive training that places practical knowledge and techniques into industry where it influences strategic decision makers.

In deciding where to start we were influenced by discussion on the international knowledge management forum ACTKM, to go for the low hanging fruit also at least attempt to solve some intractable problems. From a range of suggestions were discussed, it was decided to begin by taking results of our own research and speculate on applications of these for climate change solutions. We hope this will encourage others to do the same. A report was compiled of these (reference removed for reviewing) and officially launched in order to achieve Objective 1. Conference panels, workshops and papers, such as this one, also aim to fulfill Objective 2. It is hoped that promotion of Objects 3 and 4 will follow from this. We have just submitted a proposal applying for support to initiate work on Objectives 5 and 6. Progress on these can be reported at the conference.

CONCLUSION

The motivation this paper is to put climate change on the IS agenda and to bring IS into the forefront of a critical challenge facing the 21st Century world. In doing this, we believe that IS professionals as part of society have a position on the question of what to do about climate change in an economically responsible way. We should be thinking of how we can combine our concern for this problem with the work we do in IS and where we have expertise to contribute. This is a global issue but it is possible to begin locally as we have done, i.e. recognizing the situation here in our country Australia and providing examples of our own relevant expertise, capability and technologies that can be brought to the national discussion.

The urgency of the problem here is driving government policy, such as Emissions Trading Schemes, into unknown territory where information and information systems will be critical. However, the current discourse on IT and climate change views IT in a negative light, as a polluter. Many of us recognize that we all live in a massive, inter-connected *Planet Earth Supply Chain* and ICT provides a range of tools to *model*, *manage* and *optimize* this supply chain. We propose that the IS community can take a more positive stance and promote itself as a provider of solutions to environmental problems. In this paper we have reported the results of our multidisciplinary activities that have mapped out some of the IS territory in the climate change landscape, proposed a set of objectives that we plan to follow and described what we have already done. We believe that we need to continue to identify issues, benefits, challenges, possible resistance, and potential solutions. We would like to mobilize the international IS profession to become involved in the politics, the social issues and the necessary cultural shifts.

REFERENCES

1. ACS (2007) ACS Policy for Green IT available at http://www.acs.org.au/acs_policies/docs/2007/greenictpolicy.pdf
2. Boudreau M. Chen A. Huber M. (2008) Green IS: Building Sustainable Business Practices a chapter in Richard Watson ed. Information Systems: a Global Text project http://globaltext.terry.uga.edu/

3. Computers Off Australia http://www.computersoff.org/
4. DCC (2008) Australian Government Department of Climate Change Green Paper and Department of the Environment, Water, Heritage and the Arts http://www.climatechange.gov.au/index.html
5. Fernandez W. Bergvall-Kareborn B. Djordjevic M. Lovegrove K. Fernandez Velasco J. Talent M. (2008) How IS Design can Contribute to major Climate Mitigation Projects, ISF Conference, Canberra.
6. Fuhr J Pociask S. (2007) Broadband Services: Economic and Environmental Benefits a paper for the American Consumer Institute, available at http://www.aci-citizenresearch.org
7. Garnaut Climate Change Review Final Report (2008) available at http://www.garnautreview.org.au/domino/Web_Notes/Garnaut/garnautweb.nsf
8. GeSI (2008) SMART 2020 Report by GeSI and The Climate Group, available at http://www.gesi.org/
9. (reference removed for reviewing
10. Ghose A. K. and Koliadis G. (2007) Actor eco-systems: From high-level agent models to executable processes via semantic annotations. Invited paper (based on keynote address) in Proc. of the 2007 Engineering Semantic Agent Systems Workshop , IEEE Computer Society Press.
11. Gore A (2006) An Inconvenient Truth DVD and companion book, An Inconvenient Truth: The Planetary Emergency of Global Warming and What We Can Do About It,
12. Harvey P., Chang C. and Ghose A. K. (2006). Support-based distributed search: A new approach for multi-agent constraint processing. Argumentation in Multi-Agent Systems, N. Maudet, S. Parsons and I. Rahwan (eds.), Springer Lecture Notes in AI 4766.
13. Hasan H. Crawford K (2007) Knowledge Mobilisation in Communities through Socio-Technical System, Journal of Knowledge Management Research and Practice 5/4 237-248.
14. Hasan H. (2005) Socio-Technical Systems: from individual transaction to situated community activity, in G. Whymark and H. Hasan (eds) Activity as the Focus of Information Systems Research, Knowledge Creation Press, UCQ, 29-46.
15. Hsien, H.H, Spedding, T.A. Bainbridge, I., and Taplin, D.M.R (2006) Creating A Green Supply Chain: A Simulation and Modelling Approach. in *Greening the Supply Chain* edited by Joseph Sarkis, Springer, London ISBN 978-1-84628-298-0 pages 341-361
16. NZ (2008) New Zealand Government http://www.climatechange.govt.nz/
17. Romm J Rosenfeld A. Herrmann S. (1999) The Internet Economy and Global Warming; A scenario of the Impact of E-Commerce on Energy and the Environment, The Center for Energy and Climate Change Solutions, see http://222.cool-companies.org
18. Sellen A.J. Harper R. (2001) The Myth of the paperless Office, The MIT Press, Boston.
19. Stern Review (2006) The Economics of Climate Change, available at http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/stern_review_Report.cfm
20. Taplin, D.M.R., Spedding, T.A. and Khoo, H.H. (2006) Use of Simulation and Modelling to Develop a Sustainable Production System**.** *Sustainable Development* 14, 149-161
21. UN (2007) Information technology can be harnessed against climate change, available at http://www.un.org/apps/news/printnewsAr.asp?nid=24815